What do Cr distributions in anoxic waters tell us about the $\delta^{53}Cr$ paleoredox proxy?

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Redox controls on chromium stable isotope distributions ($\delta^{53}Cr$) and mobility in aquatic systems have led to widespread applications of $\delta^{53}Cr$ as a powerful tracer of oxygen availability throughout time (e.g. [1], [2]). A key component of these applications is the framework that:

- Oxic subaerial weathering is the principle factor driving isotopically heavy $\delta^{53}Cr$
- Under anoxic conditions, Cr is efficiently reduced and sequestered into sediments, resulting in no isotope fractionation between the water column and sediments (e.g. [3], [4]).

Within this framework, excursions in $\delta^{53}Cr$ in the sediment record are interpreted to reflect changes in oxic weathering and/or the burial of isotopically heavy Cr (unfractionated from the water column) under anoxic conditions.

Here we compare new and literature data from ferruginous and euxinic basins as well as seasonally anoxic waters to assess mechanisms driving Cr and $\delta^{53}Cr$ distributions. Fractionation during Cr removal near the redox interface results in the transfer of isotopically light Cr to anoxic deep waters. This drives Cr accumulation in deep waters, as well as $\delta^{53}Cr$ fractionation between sediments and overlying anoxic water columns. Consequently, while $\delta^{53}Cr$ distributions clearly reflect redox processes, Cr records, including in sediments deposited under anoxic conditions, likely reflect a combination of external (e.g. subaerial weathering) and internal (e.g. water column reduction with isotope fractionation) controls. Therefore, paleoreconstructions should incorporate internal fractionation processes in both oxic and anoxic settings. Future research should target mechanistic understandings of how the relative balance of external and internal processes may drive Cr distributions in the paleorecord.

References

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